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A graphical model for sustainable tourism in protected areas

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The goal of this paper is to expose a new theoretical model that tries to consider jointly ecological, socio-cultural and economic aspects of sustainable tourism in protected areas. This graphical model, called VQ-MS, is divided into four quadrants corresponding to: relations between the tourists and the environment, tourist satisfaction, average tourist spending and tourism economic impact. This model is an initiative to promote interdisciplinary researches and to study the question of sustainable tourism with multi-criteria analyses. In order to implement this model, we assume that it can constitute an additional management system and can be applied to many situations in protected areas.

Keywords: sustainable tourism, protected areas, ecological-economic modelling, multi-criteria analysis, visitor management system

1. Introduction

The goal of this paper is to expose a new theoretical model for sustainable tourism in protected areas. The term "sustainable tourism" is derived from the general concept of sustainable development, defined in [1] as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." After the emergence in the literature of multiple definitions of sustainable tourism (see [2]), this concept was formulated on an international scale at the World Conference on Sustainable Tourism (island of Lanzarote, 1995): "Tourism development shall be based on criteria of sustainability, which means that it must be ecologically bearable in the long term, as well as economically viable, and ethically and socially equitable for local communities."

Since, every scientific discipline has made important contributions to the field of sustainable tourism. In the case of protected areas, the development of this concept has resulted in the publication of several principles, guidelines (e.g., [3]) and declarations (e.g., European Charter for Sustainable Tourism in Protected Areas). From this point of view, the protected area management frameworks developed in both the US and Canada are interesting

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examples of policy tools for sustainable tourism: among them, the Limits of Acceptable Change (LAC, [4]) system is probably the most well known.

Nevertheless, the implementation of sustainable tourism concepts remains a central issue and the goal of this paper is to propose an interdisciplinary model that links the environmental protection to the socio-economic impacts of tourism. This graphical model, called VQ-MS, is divided into four quadrants. The second part of this paper presents the quadrants 1 and 2 of the model and describes the relationship between tourist attendance and environmental quality. It shows that environmental quality is an important determinant of demand / visitor satisfaction and that an increase in the number of visitors can have negative effects on the environment.

The third section discusses the capacity of tourism to produce economic development (quadrants 3 and 4 of the model). Firstly, it introduces the characteristics and the measure of the average visitor spending. Secondly, it presents the definition of the economic impacts of tourism (EIT).

The complete VQ-MS model is presented in section five. This model provides an interdisciplinary framework of sustainable tourism, but it can also be used to evaluate the socio-economic and environmental impacts of alternative management strategies in order to help the decision making process in protected areas.

2. Tourism and the environment

The visitor attendance (noted V) is bound to the environmental quality (noted Q) by a double relation:

- the tourism activity is accompanied by significant negative effects on the environment (Q is dependent on V). The development of tourism sometimes causes the destruction of the resource which was at the origin of the attraction of the visitors (environmental impact of tourism);

- the environmental quality is an important factor of the tourist demand (V is dependent on Q); it constitutes the basic resource upon which the tourism prosperity and development depends, so that any environmental pollution compromises the viability of tourism activity. Conversely, a preserved environment contributes to the development of tourism (environmental factor of tourism demand).

According to the definitions of the World Commission on Protected Areas (these definitions are documented in [5]), the variable V can be defined by the number of visitors (a person who visits the protected area), the number of visits (a visit corresponds to an entry - the visit statistic has generally no length of data associated with it) or the number of visit-day or visit hour (if additional data on the length of stay of a visit is available). In our model, we will use the concept of number of visitor to define V. The environmental quality Q can be measured by various indicators (e.g., water quality, species richness) and indexes, like the Costanza's ecosystem health index [6].

First of all, it is important to describe the idea that each of the two variables constitutes the main factor that determines the evolution of the other. This basic assumption is more particularly adapted to the situation of protected areas, even if more general considerations on other tourist destinations can be developed.

2.1. Environmental impacts of tourism

Tourism has inevitably a large environmental impact, because of its importance and its characteristics (strong concentration of visitors on restricted periods and small areas). Recreational users are one of the major causes of direct environmental impacts in protected areas [7]. These direct impacts can concern: soils, water resources, vegetation, animal life, sanitation, aesthetic impacts on the landscape, cultural environment [8].

It is worth mentioning here that some goods (water resources, ecosystems, wildlife...) are characterized by subtractability and nonexcludability. "Subtractability" deals with whether or not one person's appropriation of a resource reduces the availability of that resource for others and "exclusion" refers to the degree to which access to a resource can be restricted [9]. These natural resources are used in common by tourists (and locals) and exclusion is difficult or impossible: they possess the characteristics of "common pool resources" (CPRs). As a result, the competition between the users leads to the "tragedy of the commons" [10], where overuse of the resources is a typical problem. Thus, the analysis of common pool resources in tourism ("tourism commons") and their management play an essential role in sustainable tourism development [11].

The consequence of the definition of common pool resources is that their quality is generally related to their level of "consumption". In other words, when the number of visitors (V) increases, quality (Q) decreases and the negative effects on quality are generally cumulative.

The simple relation connecting Q to V must however be developed because quality also depends on:

- visitor activities (a): camping, recreational fishing and hunting, walking,... ;
- visitor behaviour (b);
- tourism facilities and infrastructure (i).

But it should be noted that other variables (not related to tourism) affect the environmental quality (external effects noted x): other human activities (industry, agriculture...), non-native species and natural ecosystem cycles.

Therefore, the relation between Q and V is much more complex and the function $Q = f(V, a, b, i, x)$ can take diverse forms: linear, curvilinear or even step-like [12]: the

impacts of visitors vary according to their number and nature and the characteristics of the site in terms of behaviour and resilience to the presence of humans [13]. In this theoretical framework, we will use a negative curvilinear function between Q and V (figure 1). In a more complete analysis, we can also consider the social and cultural impacts of tourism with a new function $C = h(V, a, b, i)$, where C is a social and cultural indicator.

From an empirical point of view, even if the impacts of the human activities on the environment are better known, the construction of such a function remains difficult. The definition of the ecological impacts of tourism actually encounters several difficulties [14]:

- the impacts due to each tourist activity of those due to natural phenomena and other human activities are difficult to distinguish;
- the impacts of the facilities and services related to tourism are difficult to measure, insofar as they are shared with other activities (e.g., transport);
- baseline data over long periods allowing to measure and explain impacts are often lacking (weakness of the indicators);
- human and natural impacts may have spatial and temporal dimensions which are not easy to see or understand.

2.2. The impact of the environment on tourism

Tourism demand is influenced by many factors. In accordance with our basic assumption, the number of tourists (V) depends initially on the environmental quality (Q). The importance of environment variables in attracting visitors is significant, particularly on protected areas.

Other explanatory variables of V are relative to the tourism supply in terms of quantity and quality:

- a : possible tourist activities;

- i: facilities and infrastructures related to tourism;
- p: relative prices (of tourism goods and services);

Lastly, it is essential to consider a whole set of socio-economic explanatory variables (e) among which the demography, the economy (income), the mobility and the family, the work, the consumption and the consumers system of values.

To give an example, the exploratory study of these determinants in the French case insists on the major phenomena which are: the ageing of the population, the fragmentation of the households, the rise of the role of the women, the education, the inequalities, the new forms of activity and work...

The demand function $V = g(Q, a, i, p, e)$ will be considered in the following pages as a simple positive function. The double relation between V and Q can be shown in figure 1:

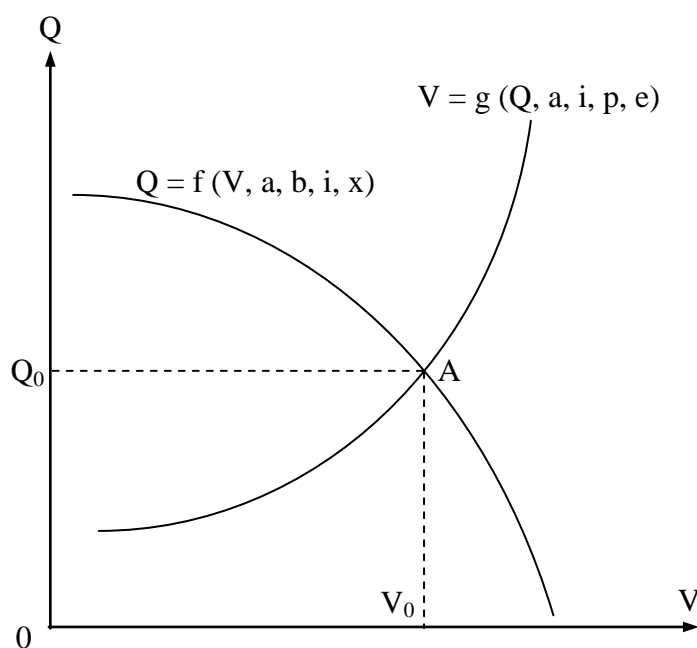


Figure 1. Relationship between the number of visitors and the environmental quality.

In this figure the environmental quality and the number of visitors are closely dependent and point A represents the situation of equilibrium (V_0, Q_0) . However, this situation of equilibrium would be seldom reached in reality or would not be durable (because of the fast evolution of the parameters a, b, e, i, p and x). More specifically, the observed value of Q will be important to determine the visitor utility.

2.3. Visitor utility

An increase of the consumer's utility can generally be measured by the consumer's surplus symbolized by the area between the ordinary demand function and the horizontal line drawn at the equilibrium market price. This area represents the amount that consumers benefit by being able to purchase a product for a price that is less than they would be willing to pay.

In the lower part of figure 2, the ordinary demand curve is noted D_m (this demand curve shows the maximum amount a visitor would be willing to pay for each level of Q). The line of price is the x-axis on which the price is equal to zero, a typical case with a pure collective good, like wildlife or quality of the air (noted like previously Q). The "consumption" of Q , for which there is no market and thus no price, is determined by its initial available quantity Q_0 . The consumer's surplus (or the amount of value the visitor receives over and above what he was required to pay) is equal to the area OP_0CQ_0 .

The higher part of the figure indicates the indifference curves for two levels of utility (U_0 and U_1) between the environmental quality Q and the income M (M can be interpreted as the sum of the other goods that can be consumed by an individual and M is independent of Q). The environmental quality Q_0 corresponds to the point A on the indifference curve U_0 . An increase in the environmental quality (from Q_0 to Q_1) means a rise of the satisfaction from A on U_0 to B on U_1 (initial income M_0 is not affected by the increase of Q). The increase in the consumer's surplus that results from this increase corresponds to the area Q_0CDQ_1 . In fact, the variations of environmental quality do not have effects on the income (M_0) and the result is a gain in utility for the visitors (higher indifference curve).

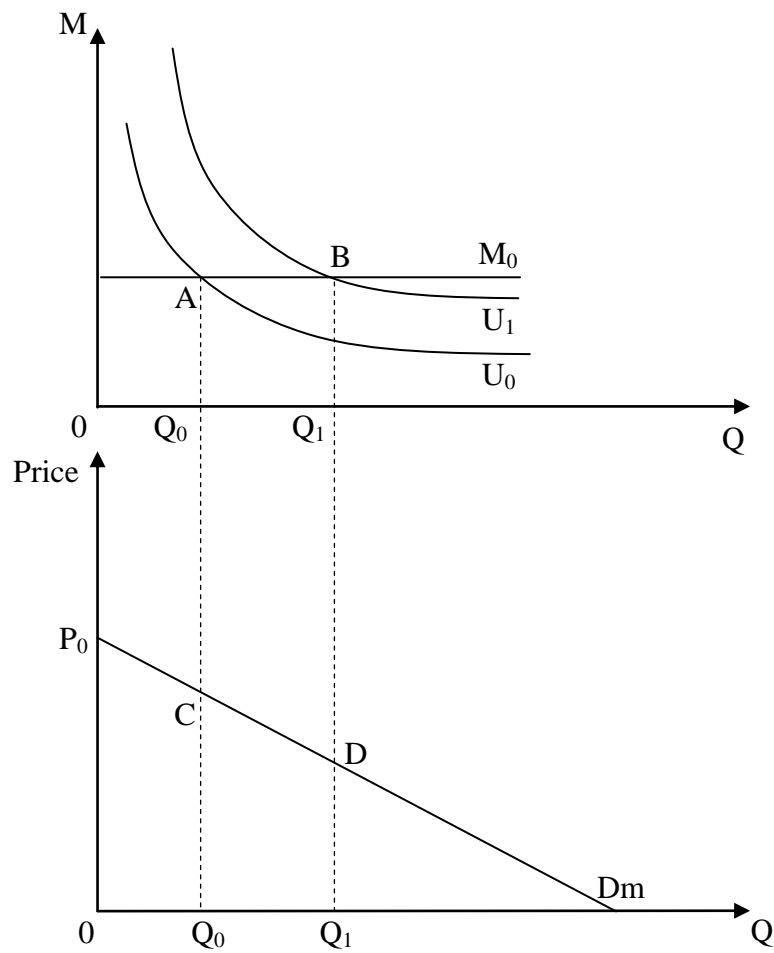


Figure 2. Indifference curves and consumer's surplus.

We can link the analysis of the visitors' utility (or satisfaction) to the relations defined previously in a new figure: the observed environmental quality Q_0 corresponds to point B on the indifference curve U_0 (quadrant 2).

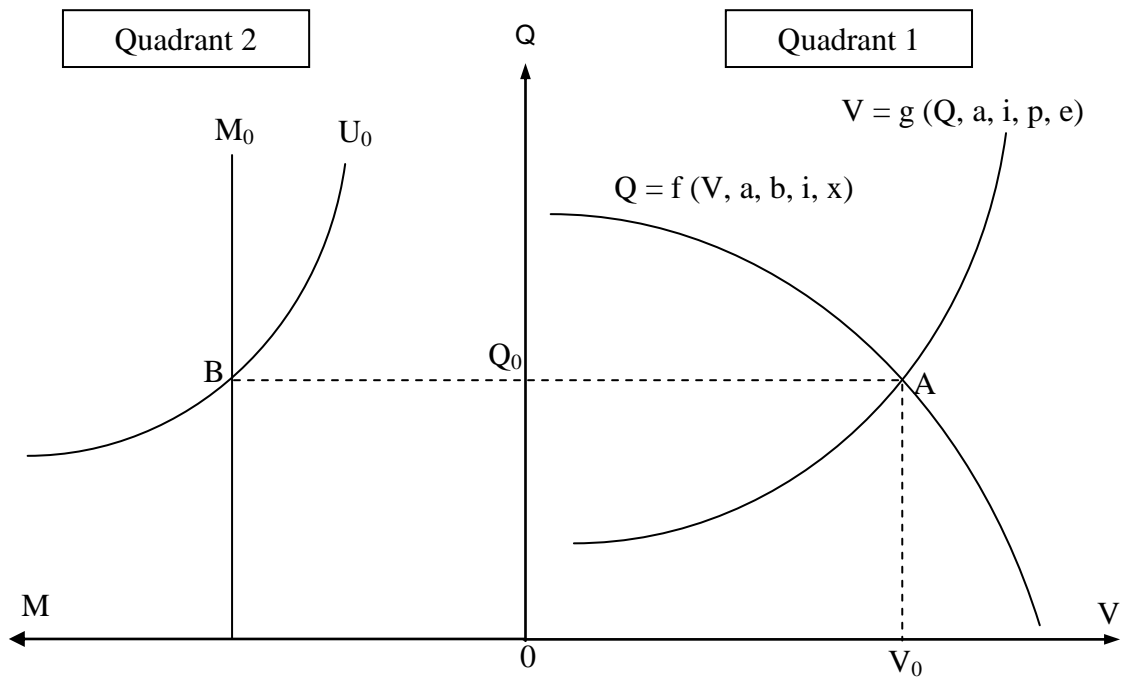


Figure 3. Relationship between number of visitors, environmental quality and visitor satisfaction.

Despite the importance of the relations between tourism, environment and satisfaction highlighted in this first section, we should not overlook the fact that tourism is often a major source of economic development for some areas (economic aspect of the definition of sustainable tourism).

3. Economic impact analysis of tourism

Tourism in protected areas constitutes a significant source of economic development significant for many regions. Visitor spending impacts the local economy in terms of sales, income, employment and value added. In this section we will first study the characteristics and the evaluation of the visitor spending, before considering the total economic impact.

3.1. Average visitor spending

The value of the average visitor spending generally comes from visitors surveys; sometimes, it is adapted from studies on comparable sites. This estimation must be based on a representative sample of the visitor population by considering the variations between the seasons, the types of tourists and the geographical distribution in the area concerned.

In order to determine the total economic impact, more complete information about the amount of spending must be obtained [15]. It is then necessary that spending should be estimated for different subgroups of visitors (campers, day users, visitors in campgrounds, etc.) and for several spending categories (lodging, food, transportation, recreation, souvenirs, etc.).

Beyond the simple observation of the tourist expenditure, it is interesting to discuss the spending variations that result in changes in income.

If we refer to Engel's laws, as income rises, the percentage of income spent on food decreases, while the percentage spent on clothing and housing remains constant. At the same time, the percentage of income spent on luxuries (e.g., transport and telecommunication, leisure, vacations) increases.

Income elasticity of demand can be used to define the various goods: it measures the relationship between a change in quantity demanded and a change in income (the basic formula to calculate income elasticity of demand is: percentage change in quantity of good G divided by the percentage change in real income):

Table 1. Income elasticity of demand.

Income elasticity of demand (ied)	Goods	Demand
≥ 0	Normal goods	
> 1	- luxuries	- demand rises with the income but more than proportionally
$0 < \text{ied} < 1$	- necessities	- demand rises with the income but less than proportionally
< 0	Inferior goods	- demand falls as income rises

The Engel's curves (demands for a necessary good G_1 and a luxury good G_2 as the income changes) thus have the following forms:

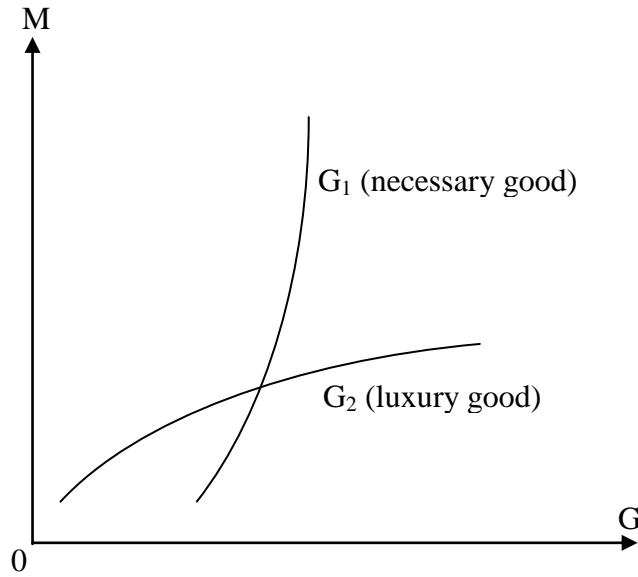


Figure 4. Engel's curves for a necessary good and a luxury good.

In general, tourism has an income elasticity of demand greater than 1. This is an empirical fact for many regions, and we will accept this hypothesis for the moment: in the framework of our theoretical model, the relationship between the income (M) and the average visitor spending (S) will take a similar form to the Engel's curve for luxury goods. The initial income M_0 will thus determine the average visitor spending S_0 .

Nevertheless, it is necessary in a more complete demand analysis to take some elements into account: the consumption habits, the social groups, the household size, the tourist's motivation, opinions, etc. In this manner, the heterogeneous character of the budgets can change the form of the curve, even for households having rather close levels of income. Therefore, the income elasticity of demand may be quite different if we consider that the visitor expenditure is made up of leisure goods but also of necessary goods (food, lodging).

The analysis of the evolution of the tourist expenditure after a variation of the relative prices (of the tourist activities and services related to tourism) must be considered with similar prudence. In general, the demand curve is a decreasing function: the more the price decreases,

the more the demand increases (the price elasticity of demand measures the responsiveness of the quantity demanded of a good to its price). But the demand can also vary in a different way according to the product or the general economic situation (it may be possible that demand for a good rises as its price rises). The demand for a good can also be affected by a change in the price of another good: this effect is measured by the cross elasticity of demand. For example, if the price of a tourism activity decreases, this will cause an increase in the sales of derived products (complementary goods) and a decrease in the demand for the concurrent activities (substitute goods), but that will not affect the demand for lodging (independent goods). The variation of the tourist expenditure according to the trend of prices is thus very uncertain when it relates to a whole of diversified consumer goods and services.

From an empirical point of view, numbers of models have tried to estimate the tourism demand, in term of number of tourists as well as their expenditures. These predictions are generally based on judgement (Delphi method), time series methods or structural models. In a review of one hundred international demand models [16], it is showed that the majority of these studies follow a single-equation time series approach, while only nine studies used panel data and nine used cross-section data.

In the context of national studies, satellite accounts (that extract tourism-related activity from a system of national accounts) are generally used. When spending is desired for particular market segments or for local regions, survey approaches are necessary. They constitute the first step to determine the total tourism economic impact.

3.2. Economic impacts of tourism

The analysis of the contribution of the tourist activity to the economic development is to determine the impact of the total tourist expenditure on the area of destination. Total spending

is usually calculated by multiplying the average spending (per visitor, visits, etc.) by the visitor numbers. The units of the two variables must obviously be compatible. In our model, the total visitor spending is obtained by multiplying the average visitor spending (S_0) by the number of visitors (V_0): area OS_0EV_0 in figure 5.

In reality, the tourist spending statistics (official or revealed by surveys) do not give a precise idea of the real impact of this activity on the economy. The capacity of tourism to produce economic development must be approached by studying the various effects of an injection of tourist expenditure. The initial tourist spending on goods and services in hotels, restaurants, shops, etc. creates changes in sales, income and jobs in the local area (direct effects). From the direct expenditure, tourism establishments will pay out wages to the local employees and will reconstitute their stocks from local suppliers and wholesalers: the changes in sales, income and jobs in "backward-linked" activities are called indirect effects. Lastly, the income earned through the direct or indirect effects of the visitor spending will generate a rise in the local consumption expenditure: these additional turnover, income and job opportunities are called induced effects. The sum of the indirect and induced effects constitutes the secondary effects, in opposition to direct effects which result from the initial increase in the tourist expenditure. It is however significant to note that these effects are limited by the savings, the payments of taxes to the central and local governments and the imports induced by the additional expenditure.

The effects of an increase in the tourist expenditure can be captured by multipliers. Four types of tourism multipliers are in common use: the sales multiplier, the output multiplier, the income multiplier and the employment multiplier [17]. Within these categories, there are many different kinds of multipliers used to estimate the secondary or multiplier effects; for example, the Type I sales multiplier indicates the ratio of direct and indirect sales to direct

sales while the Type II sales multiplier indicates the ratio of direct, indirect and induced sales to direct sales.

Although the analyses of these secondary effects are often sophisticated, the economic impacts of tourism (EIT) can be estimated by the simple equation:

$$\text{EIT} = \text{number of tourists} * \text{average spending by visitor} * \text{multiplier}$$

In our model, EIT are symbolized by the area 0FGV₀:

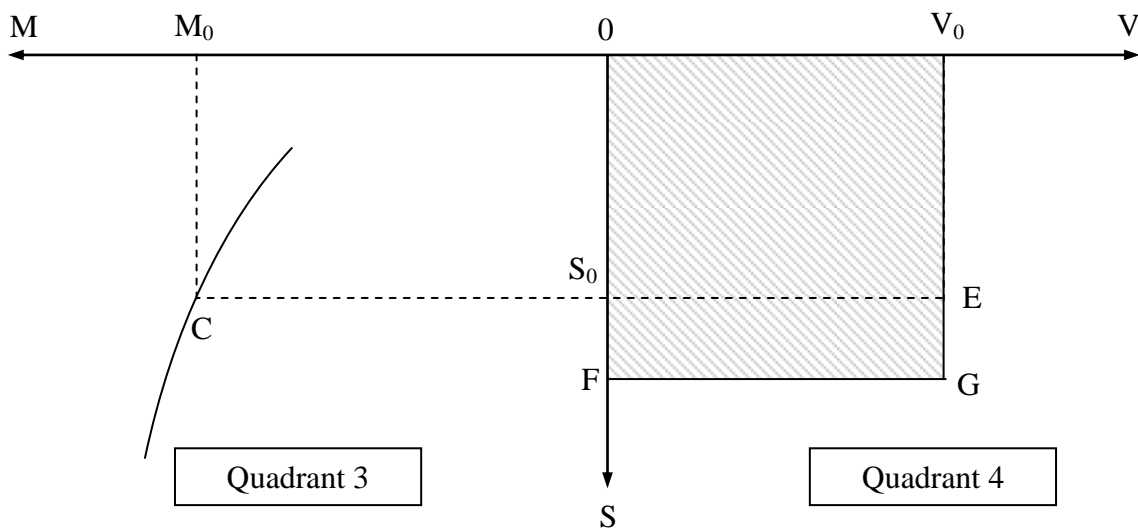


Figure 5. Average visitor spending and economic impacts of tourism.

The evaluation of the multipliers necessitates the use of models, more or less sophisticated: a base model (where two sectors - export activities and local activities - are linked by stable and linear relationships), a keynesian model (where additional income and employment are generated in "rounds" and diminish in geometric progression) or an input-output model (I-O model). The input-output models (see [18,19]) are probably the more frequently used tools to evaluate economic impacts from tourism: they express a relationship of the different economic sectors in matrix form, built on the result of a study of the effects of tourist expenditure.

For example, the US National Park Service's (NPS) Money Generation Model (MGM) and its update (MGM2) are input-output models which estimates the impacts that NPS visitors have on the economy of protected areas in terms of their contribution to sales, income

and jobs [20,21]. In the MGM2 model, visitors are divided into eight distinct subgroups and visitor spending is itemized in twelve spending categories.

4. A theoretical model for sustainable tourism in protected areas

4.1. The VQ-MS model and interdisciplinary researches

The relations described in section 2 (quadrants 1 & 2) and section 3 (quadrants 3 & 4) link the principal variables of sustainable tourism: number of visitors, environmental quality, visitor satisfaction and economic impact of tourism. These variables are closely intertwined and we can draw the full VQ-MS model (from the name of the axes of the four quadrants) in figure 6:

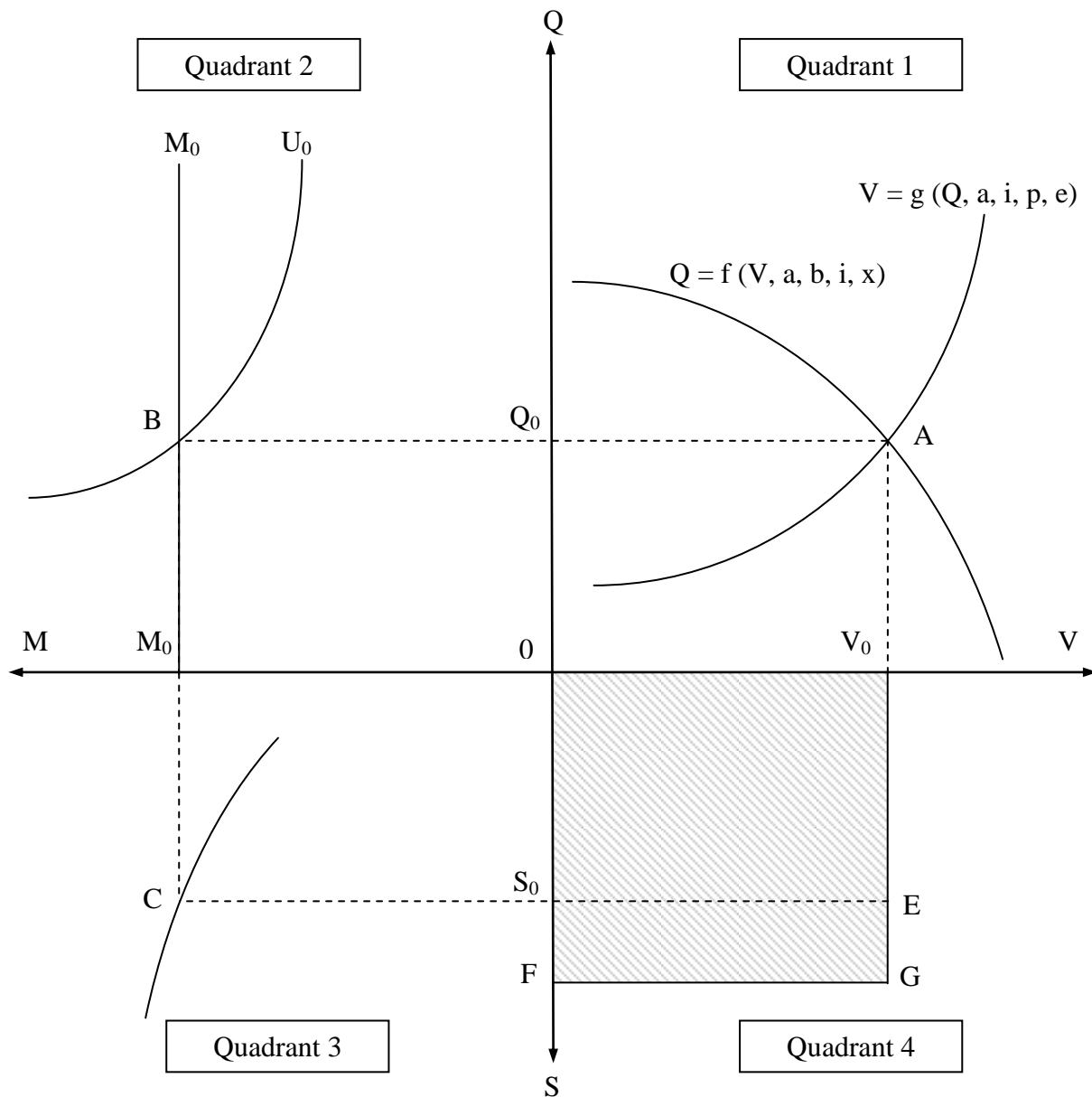


Figure 6. The VQ-MS model.

This model tries to connect interdisciplinary researches on sustainable tourism in protected areas. Firstly, the challenge is to define and measure a range of sustainable indicators for all three aspects of sustainable tourism: ecological, social and economic. Several sets of indicators have been proposed in an effort to facilitate the implementation of sustainable tourism (e.g., [22,23,24]). In protected areas indicators should be defined for this local scale of application. In our model they should be meaningful of:

- the visitor attendance (number of visitors, visits...);

- the environmental quality (index of biodiversity, water and landscape quality,...);
- the socio-cultural environment (integrity of the local culture, number of resident complains...);
- the visitor satisfaction;
- the economic impact of tourism (average spending, multipliers...);

Secondly, the four quadrants of the model allow putting together some issues often divided in the sustainable tourism literature. More specifically, we can summarize in the following table some of the main research subjects on sustainable tourism:

Table 2. Examples of research subjects on sustainable tourism.

Research subjects	Scientific disciplines	Quadrants
Determinants of tourism demand (number of visitors)	Economics, sociology	1
Ecological impacts of visitors and related activities (importance, geographical location...), ecological impacts of other human activities or natural phenomena, natural evolution of ecosystems.	Natural Sciences	1
Socio-cultural impacts of visitors	Sociology	1
Visitor satisfaction	Sociology	2
Environmental valuation, willingness to pay (WTP) for environmental quality	Economics	2
Determinants of tourism demand (average spending)	Economics, sociology	3
Economic impacts of tourism	Economics	4

4.2. *The VQ-MS model and visitor management*

During the 1970s, the traditional concept of carrying capacity (maximum number of visitors without unacceptable alteration in the environment and without a decline in the visitors' satisfaction) was a general approach for recreation management. Because of the limitations of this concept (due to the lack of a clear and predictable relationship between use and impact) a variety of more sophisticated frameworks, which focus on determining the desirable conditions for the visitor activity, have been developed in both the US and Canada:

- LAC: Limits of Acceptable Change;
- ROS: Recreation Opportunity Spectrum;

- VIM: Visitor Impact Management;
- VERP: Visitor Experience and Resource Protection;
- VAMP: Management for Visitor Activities Management Process.

The origins and comparative analysis of these systems have been widely described in the literature [25,26]. These frameworks, used in various parks and protected areas around the world, follow the four basic planning steps [27]: "(1) determining the current situation (2) deciding what situation is desired (3) establishing how to get from the current to the desired situation using certain management actions (4) monitoring and evaluating progress or success in attaining the desired situation".

We presume that the VQ-MS model could constitute an additional management system. According to the previous methodology, this system will also follow four steps:

(1) Determining the current situation of the basic indicators (V, Q, U, M, S) of the model (and use-impact relations if possible) for each site and period (quadrants 1 to 4);

(2) Deciding what environmental (or socio-cultural) situation is desired (e.g., rise of Q) and discuss the management tools which can be used to accomplish this goal. It is worth mentioning here that each of these tools will have an influence in quadrant 1, moving the curves $V = g(Q, a, i, p, e)$ and $Q = f(V, a, b, i, x)$:

Table 3. Visitor management goals and tools (adapted from [3]).

Goals	Tools (examples)	Parameters
1. Reduce use of the entire protected area	- Limit number of visitors in the entire area - Charge a visitor fee	i p
2. Reduce use of problem areas	- Establish skill/equipment requirements - Make access harder/easier to areas	a i
3. Modify the location of use within problem areas	- Locate facilities on durable sites - Prohibit off-trail travel	i a
4. Modify the timing of use	- Encourage use outside of peak use periods - Fees in period of high use	a p
5. Modify type of use and visitor behaviour	- Teach a wilderness ethic - Discourage/ban damaging practices/equipment	b a
6. Modify visitor expectations	- Inform visitors about appropriate uses	b
7. Increase the resistance of the resource	- Shield the site from impact - Strengthen the site	i x
8. Maintain/rehabilitate resource	- Maintain/rehabilitate impacted locations	x

(a = activities; b = behaviour; i = facilities and infrastructure; p = prices; x = external factor)

(3) Simulating the effects of the various strategies on the value of the basic indicators (ecological, social and economic) in order to determine the best choice. The simulation process for each objective can be based on complex models (e.g., ecological models, input-output models), on visitor and local surveys or on expert opinion. In this context, multi-criteria analysis (MCA) is an appropriate form of decision-making because it allows considering side by side monetary and non-monetary units. For example, we can present in the following table our basic indicators of sustainable tourism and the evaluation of three hypothetical management alternatives (A, B and C):

Table 4. Indicators-alternatives matrix.

Indicators \ Alternatives	A	B	C
Environmental quality: Q (quadrant 1)	+ 4 %	+ 10 %	+ 6 %
Economic impacts: V*S*multiplier (quadrant 4)	- 4 %	0 %	+ 3 %
Visitor satisfaction: U (quadrant 2)	+ 6 %	- 6 %	0 %
Socio-cultural context: C (quadrant 1)	+ 2 %	+ 3 %	- 5 %

Using all indicators, this table shows that no alternative is better than the others. Each option actually increases the environmental quality but reduce one of other indicators. In this case, the indicators have to be weighted according to their perceived importance and the expert judgment is one solution to provide the weights. The final ranking of the alternatives can thus be obtained for making decisions using various methods. Because of the weighting process and the frequent lack of scientific knowledge about the impacts, the MCA process is necessarily subjective (the same subjectivity is present in all planning and management frameworks). Furthermore, the necessary involvement of the stakeholders (all the groups who have a direct interest in protected areas) and the need to consider the conditions of feasibility (available staffing resources and funding) must also influence the decision process.

(4) Implementing actions and monitoring. The results of monitoring (i.e. measurement of the key indicators) help managers to evaluate the effectiveness of their actions and to take new decisions in the future.

5. Conclusion

From a theoretical point of view, the VQ-MS model tries to consider jointly ecological, socio-cultural and economic aspects of sustainable tourism. This consideration of topics that had often been treated separately is an initiative to promote interdisciplinary researches. In that sense, we think that the question of sustainable tourism is too complex to be analysed with a single criteria: an ecological manager may ignore the possible economic effects of his decisions. On the other hand, an economic cost-benefit analysis in which gains and losses are in the same units (prices) can seem inappropriate for valuing the various aspects of environmental changes. Ultimately, the multi-criteria analysis is obviously the best decision making process for our framework.

The model presented here has not yet been used to resolve concrete problems but we think that it can be applied to many situations in protected areas. It is the reason why the future developments of interdisciplinary researches and the implementation of the model in experimental management systems will be necessary to develop this concept in an empirical way.

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